

Mean-field description of rotating ellipsoids in the rare earth region

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2 December
Brussels

Mean-field
description of
rotating
ellipsoids in
the rare earth
region

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Mean-Field
Symmetries

Rare-Earths:
 ^{158}Er

Progress and
Outlook

1 Mean-Field Symmetries

2 Rare-Earths: ^{158}Er

3 Progress and Outlook

Symmetry

For an effective interaction:

$$\hat{U}^\dagger \hat{H}_{(effective)} \hat{U} = \hat{H}_{(effective)}$$

Symmetry

For an effective interaction:

$$\hat{U}^\dagger \hat{H}_{(effective)} \hat{U} = \hat{H}_{(effective)}$$

Rotation	$\hat{\vec{J}}$	$J = 0, \frac{1}{2}, 1, \dots$
Parity	\hat{P}	$p = \pm 1$
Time Reversal	\hat{T}	N.A.

Symmetry-Breaking Codes

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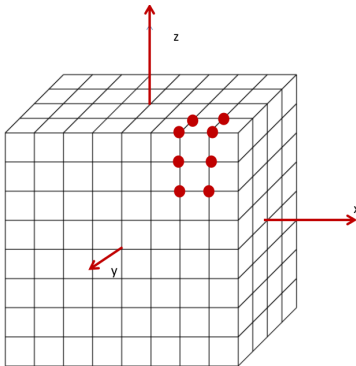
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Hartree-Fock(-Bogoliubov) equations on a lattice
This allows for a natural breaking of **all** symmetries.



Break all symmetries?

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Time Reversal

\hat{T} : reverse all momenta

Breaking describes e.g. odd nuclei

Parity

\hat{P} : reverses all space coordinates

Breaking describes e.g. assymmetric fission

Signature

$\hat{R}_{x,y,z}$: Rotate the system along the x , y or z axis by π

Breaking describes e.g. M1 Bands in ^{198}Pb

'Nudging the system in the right direction'

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How to break a symmetry:

- 1 Create a phase-space that allows for all (or most) configurations that break the symmetry
- 2 Take an operator \hat{A} that breaks the symmetry
- 3 Modify Hamiltonian: $\hat{H}' = \hat{H} - \lambda \hat{A}$
- 4 Solve the HFB equation for \hat{H}'

Examples:

- \hat{Q}_{30} breaks parity, solution is an octupole deformed nucleus.
- \hat{J}_z break Time Reversal, solution is a rotating nucleus.

Cranking (in different directions)

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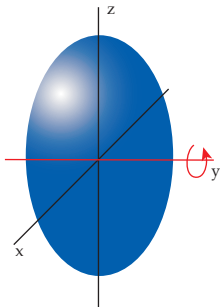
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Conservation of \hat{R}_y only allows $\hat{\vec{J}}$ along the y axis!

$$\hat{H}' = \hat{H} - \omega \hat{J}_y$$



Cranking (in different directions)

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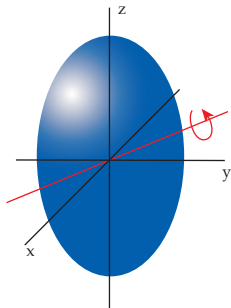
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Breaking \hat{R}_y , we can let the nucleus turn in any direction!

$$\hat{H}' = \hat{H} - \omega_x \hat{J}_x - \omega_y \hat{J}_y - \omega_z \hat{J}_z$$



A Triaxially(?) deformed band in ^{158}Er

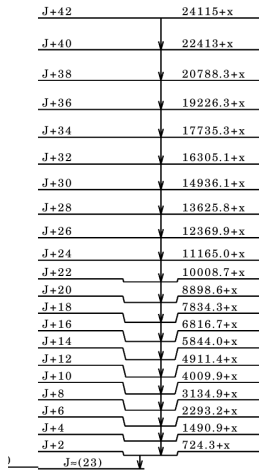
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Data from the NNDC

Several Minima

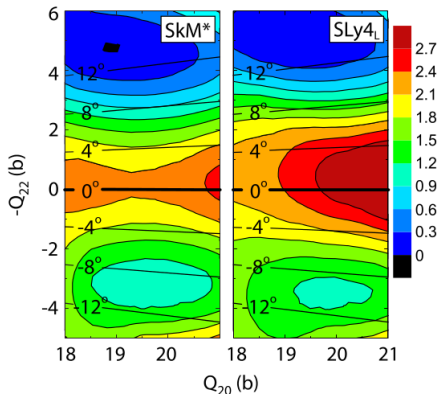
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$$\omega = 0.7 \text{ MeV}$$

From Y. Shi et al., PRL 108, 092501 (2012)

Reorientation of the rotational axis

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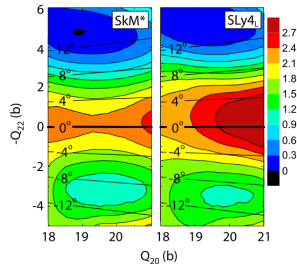
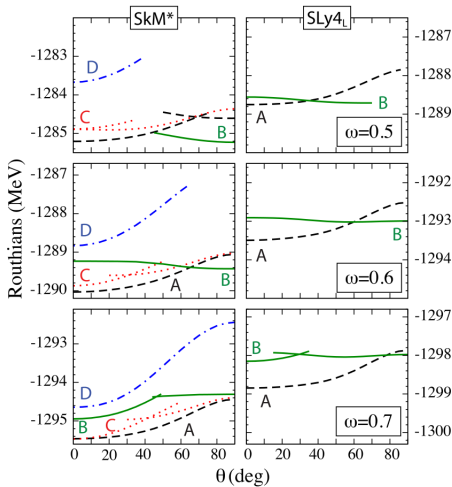
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The Physical Minimum

From Y. Shi et al., PRL 108, 092501 (2012)



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Development of the MOCCa code

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MOCCa = **M**odular **C**ranking **C**ode
Arbitrary Breaking of Symmetries

Development of the MOCCa code

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MOCCa = **M**odular **C**ranking **C**ode
Arbitrary Breaking of Symmetries

Status

- \hat{P} , \hat{R}_z , \hat{T} breaking

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MOCCa = **M**odular **C**ranking **C**ode
Arbitrary Breaking of Symmetries

Status

- \hat{P} , \hat{R}_z , \hat{T} breaking
- Testing ongoing

Development of the MOCCa code

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MOCCa = **M**odular **C**ranking **C**ode
Arbitrary Breaking of Symmetries

Status

- \hat{P} , \hat{R}_z , \hat{T} breaking
- Testing ongoing
- Slow....

Deformation of ^{240}Pu

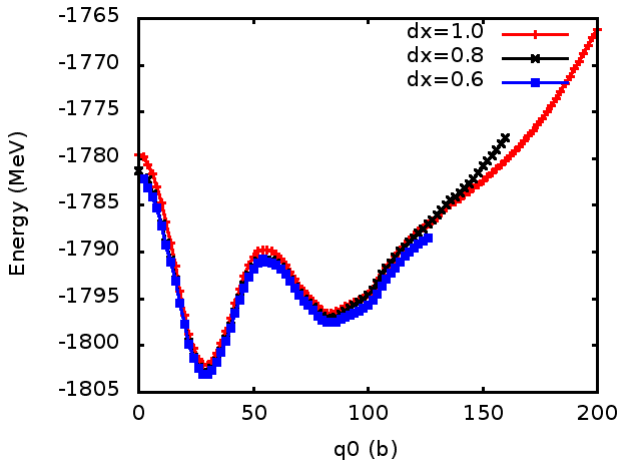
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First application of the MOCCa code: breaking \hat{R}

- Similar complicated structure in $^{138-140}\text{Nd}$
- Signature bands in ^{196}Pb